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HABITAT COMPOSITION OF MAURITIUS KESTREL HOME RANGES

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Abstract.—Loss of its original native forest habitat has been identified as one cause of the population decline of the Mauritius Kestrel (*Falco punctatus*). During the 1988–1989 breeding season we examined the size and habitat composition of the home ranges of two pairs of nesting Mauritius Kestrels, one located in a traditional location and the other in a new nest cavity at the edge of agricultural fields and other non-native vegetation. Kestrel home ranges were determined by radio tracking. Habitat types were identified using overstory canopies only. Native vegetation composed 12–41% of kestrel home range area, with exotic woodland, agricultural land, and scrub composing 15–40%. Kestrels were observed taking prey from non-native habitats, and both pairs fledged young. These Mauritius Kestrels appear to have adjusted successfully to non-native habitats.

COMPOSICIÓN DEL HABITAT QUE OCUPA *FALCO PUNCTATUS*

Sinopsis.—Una de las causas de la reducción poblacional del Falcón de Mauricio (*Falco punctatus*) ha sido la pérdida de habitat por la destrucción de sus bosques nativos. Durante la época reproductiva de 1988–89 examinamos el tamaño y composición del habitat de áreas utilizadas (home ranges) de dos pares de falcones. Una de estas localidades se encontraba en un área tradicional y la segunda en el borde de un campo agrícola con vegetación no-nativa. Las áreas utilizadas por las aves fueron determinadas utilizando radio localización. Se identificaron los habitats utilizando tan solo la vegetación del docel del bosque. De un 12–41% del área de utilización de las aves estuvo compuesta de vegetación nativa y de un 15–40% de árboles exóticos, tierra agrícola y vegetación arbustiva. Ambas parejas criaron en los dos tipos de habitats y se observaron a los falcones cazando en el área con vegatación no-nativa. El Falcón de Mauricio parece haberse ajustado adecuadamente a habitats no-nativos en su lugar de origen.

The Mauritius Kestrel (*Falco punctatus*), one of the rarest falcons in the word, is endemic to the island nation of Mauritius in the southwestern Indian Ocean (Temple 1977, Cade 1982, Jones and Owadally 1988). Because of its preference for arboreal geckos and method of still-hunting, which requires an open canopy, the Mauritius Kestrel was thought to be dependent upon native forest (Temple 1974, 1977, 1987; Jones and Owadally 1988). Most of the kestrel's original native forest habitat has been lost to cultivation or commercial development (Cade and Jones 1993). The remaining native forest is severely altered by invasion of exotic plant species, which change the composition, structure, and density of the forest canopy and the understory vegetation, in turn affecting the availability of potential prey species. By 1974, Mauritius Kestrels had declined to a

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low of four individuals in the wild (Temple 1977). Intensive conservation efforts, including release of captively bred birds and those reared from harvested eggs into areas of native vegetation and other habitats (Jones et al. 1991), have led to recovery of this species.

Here we describe the size and habitat composition of home ranges of two pairs of nesting Mauritius Kestrels occupying heterogeneous habitats during the late 1980s. One pair occupied a traditional nest cavity in the region of the greatest remaining native forest, and the other occupied a new nest cavity at the edge of degraded forest and agricultural fields.

METHODS

Study area.—Mauritius is an oceanic, subtropical island (1860 km^2) in the southwestern Indian Ocean, 800 km east of Madagascar. Since colonization began in the 17th century, most of the island has been cleared for cultivation and development. Inhabited by more than one million people, most of the island remains rural. Forests are limited primarily to steep ridges and gorges and some riparian areas. At the onset of this study, kestrels were found only in the vicinity of the Black River Gorges (55 km^2) on the southwest corner of the island, and only 10 nesting pairs were known. This area was the only region of the island not systematically treated with pesticides (Cheke 1987). Native trees still occupy most of the gorges, but many areas are dominated by one or more exotic species, and other areas are a mosaic of native and non-native species. The gorges are surrounded on all sides by cultivated lands, providing avenues for invasion of non-native plants.

Breeding pairs.—During the 1988–1989 breeding season, two nesting pairs of Mauritius Kestrels were studied during three nesting stages (Table 1). One pair used a traditional nest site on Mt. Zaco in the Black River Gorges. Both birds were wild (i.e., not captively reared) but had been banded several years previously and had successfully fledged young the two seasons prior to the start of the present study. The second pair nested on the Trois Mamelles massif at the fringe of the gorges. The male was captively bred and hacked approximately 3 km away, whereas the female was a wild bird. The male was observed courting the female in September 1988. The pair searched for cliff cavities facing forested and unforested aspects, and eventually chose a cavity facing agricultural land. This site was unique because it was the first nest cavity located outside forested areas.

Both pairs were provided with approximately 30 g of white mice directly below their respective nest sites daily. Supplemental feeding was believed necessary by the local kestrel conservation organization, the Mauritius Wildlife Appeal Fund, to facilitate reproductive success and conservation goals. The behavior of both male kestrels was apparently modified by this supplement because they remained near the feeding site for approximately 1–2 h prior to the feeding, and remained in the vicinity as long as the workers delivering the food remained at the site.

Habitat classification.—Native forest and many exotic tree and shrub

TABLE 1. Mauritius Kestrel home range size and habitat composition for the Mt. Zaco and Trois Mamelles nest sites in 1988–1989. The bottom portion of the table shows the percentage of habitat type within each home range, followed by the percentage of statistically independent radio tracking observations made in each habitat.

	Site				
	Mt. Zaco	Mt. Zaco	Trois Mamelles	Trois Mamelles	Trois Mamelles
Sex	male	male	male	male	female
Nesting Stage	incubation	post-fledging	nestling	post-fledging	post-fledging
Home Range (km^2)	0.80	0.80	1.54	1.61	0.79
Habitat Type (%)/Observations (%)					
Native forest	12/12	13/6	29/12	34/32	41/11
Mixed exotic woodland	40/54	40/37	1/0	0/0	0/0
Agricultural	0/0	0/0	39/61	37/47	29/38
Monotypic exotic[a]	9/0	9/2	2/0	2/0	2/2
Open ground	7/4	9/25	3/0	1/1	1/9
Rock	3/4	2/0	10/15	6/5	10/9
Scrub	25/15	24/27	15/7	18/6	16/16
River Reserves	0/0	0/0	3/5	4/9	3/16
Acacia	4/12	4/2	0/0	0/0	0/0

[a] For Mt. Zaco, this category combines the tecoma (*Tabebuia pallida*) and terminalia (*Terminalia* sp.) habitat types; for Trois Mamelles, this type was primarily Liane de Cerf (*Hiptage benghalensis*).

species on Mauritius have distinctive canopies that are readily distinguishable from one another when viewed from vantage points available in the Black River Gorges area. Native forest is heterogeneous in terms of species composition and canopy structure, and native trees are taller than most exotic vegetation. In contrast, many exotics form monotypic stands, either through deliberate planting or invasion of native vegetation. Furthermore, many exotic species have canopy structures that are too dense for kestrel flight, do not support kestrel prey, or both (Jones 1987). Kestrels hunt primarily in the inner portion of a tree's canopy by still-hunting (i.e., perching to watch prey and then pursuing by hopping or flying among the branches; Jones 1987). The structure of the overstory canopy is therefore important to kestrel ecology. By identifying habitat types based solely on overstory canopies, we produced habitat categories meaningful for kestrel research and conservation, and avoided the need to identify vegetation communities using more rigorous floristic methods requiring extensive sampling and ground truthing.

We used previous descriptions of native forest by Vaughan and Wiehe (1937, 1941) to identify native habitat types available to the breeding pairs included in this study (Table 1). Because native forest is now extensively invaded by exotic plants (Lorrence and Sussman 1988), we established a threshold of 25% canopy cover by native tree species for a habitat to be considered native forest. Forested areas with less than 25% canopy cover were defined as mixed exotic woodland. We also used Vaughan and Wie-

he's (1937, 1941) description of riparian vegetation, called river reserves. Outside of the Black River Gorges, river reserves are narrow bands of exotic trees and other vegetation, with native trees present in some locations. Agricultural lands usually abut these corridors and are typically planted in sugar cane. We identified an additional habitat type called monotypic exotic that included a single exotic species within any one mapped habitat type. Habitat patches were mapped if they were a minimum of 25 m in one dimension.

Radio tracking.—Kestrels were captured using bal-chatri traps. Radio transmitters (Terry Roundy, Salt Lake City, Utah, U.S.A.) weighing approximately 5 g (3.1–3.5% of kestrel body mass) were clipped to the two central retrices, as described by Kenward (1978, 1980). Batteries were field-replaceable, facilitating continuous tracking and minimizing handling. Three-channel receivers (RB4 "Falconer," Custom Electronics, Urbana, Illinois, U.S.A.) with three-element hand-held Yagi antennas and earphones were used to locate the birds. Signal direction was determined using the null-average method.

Kestrels were observed during three nesting stages, including incubation, nestling, and post-fledging over a 3-mo period from October 1988–January 1989. Locations were triangulated every 15 min during each observation period using at least two receivers. Sampling was conducted 0600–1800 h, at 3–10 h intervals. Each hour of the day from 0600–1800 h was sampled an equivalent number of times. We tested for independence of data points following Schoener (1981) and Swihart and Slade (1985). Upper and lower critical t^2/r^2 values were calculated for each bird. If data were autocorrelated for the 15-min observation intervals, we used longer time intervals (i.e., multiples of 15) until data achieved independence.

Home range size and habitat use determination.—Home range sizes were determined using the minimum convex polygon method (Macdonald et al. 1980, Schoener 1981). Total size of home range and habitat type areas within home-range polygons were calculated using a digitizer. From these we calculated the percentages of habitat types available to each individual kestrel during each nesting stage.

RESULTS AND DISCUSSION

Mauritius Kestrels maintained home ranges that encompassed mosaics of native and non-native habitat types (Table 1). For the Trois Mamelles pair, native forest and agricultural land each accounted for roughly 33% of the birds' home ranges, with scrub and rock making up most of the rest. Some 47–61% of the observations of the male and 38% of the female at Trois Mamelles were made in sugar cane fields. Both birds were frequently observed taking *Calontes versicolor,* a 50-g exotic terrestrial agamid lizard that was common only in sugar cane fields. This was the first recorded instance of agricultural land being used for hunting within a Mauritius Kestrel home range. Kestrels from Trois Mamelles were observed hunting on the wing, hovering, and hopping or sitting on the

ground, unusual behavior for this species. The home range of the Trois Mamelles male was >1.5 km^2, roughly twice the size of the Mt. Zaco male. However, this male was a yearling, and this was his first nesting attempt. The Trois Mamelles pair successfully fledged young the year this study was conducted.

Most of the Mt. Zaco male home range was made up of mixed exotic woodland (40%) and scrub (25%), while only 12% was native forest (Table 1). The relative proportions of these habitat types varied little between nesting stages, but the proportion of times the Mt. Zaco male was observed in each habitat type changed substantially for most habitat types from the incubation to post-fledging stage (Table 1). One of the predominant non-native trees in several habitats in the Mt. Zaco home range was *Terminalia* sp. This tree typically has large diameter branches, a relatively open canopy structure, and peeling bark, characteristics that are believed favorable for *Phelsuma* geckos, the kestrels' primary prey species (Gardner 1984, Jones 1985). Carter (1991) found that several non-native tree species in Mauritius Kestrel home ranges, including *Terminalia,* supported *Phelsuma* populations greater than those in native forest, but that other exotic species supported few geckos. The Mt. Zaco pair also successfully fledged young the year of this study.

Prior to this study, it was believed that even though home ranges included non-native habitat types, kestrels would nevertheless rely heavily on native forest for prey. Although the number of kestrels examined in this study was insufficient to draw conclusions regarding habitat use, our data show that Mauritius Kestrels selected home ranges that included relatively small proportions of native forest, and that kestrels did not appear to spend a disproportionate amount of time in native forest relative to other habitats. Supplemental feeding undoubtedly had an effect on kestrel behavior and the way in which the data can be interpreted, but the importance of supplemental feeding to Mauritius Kestrel conservation at the time of this study clearly outweighed short-term research goals. Since this study was completed, kestrels have been observed to nest in non-native habitats on many parts of the island not known to be previously occupied. By 1991 there were as many as 145 non-captive individuals on the island (Cade and Jones 1993, Jones et al. 1991), and by 1996 some 100 breeding pairs in the wild.

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LITERATURE CITED

CADE, T. J. 1982. The falcons of the world. Cornell University Press, Ithaca, New York. 188 pp.

———, AND C. G. JONES. 1993. Progress in restoration of the Mauritius Kestrel. Conserv. Biol. 7:169–175.

CARTER, J. E. 1991. Home range, habitat utilization, and prey delivery patterns of the Mauritius Kestrel (*Falco punctatus*). M.Sc. thesis. Boise State University, Boise, Idaho, U.S.A. 132 pp.

CHEKE, A. S. 1987. An ecological history of the Mascarene Islands, with particular reference to extinction and introductions of land vertebrates. Pp. 5–89, *in* A. W. Diamond, ed. Studies of Mascarene Island birds. Cambridge University Press, Cambridge, United Kingdom. 458 pp.

GARDNER, A. S. 1984. The evolutionary ecology and population systematics of day geckos (*Phelsuma*) in the Seychelles. Ph.D. dissertation. University of Aberdeen, Scotland, United Kingdom, 387 pp.

JONES, C. G. 1985. The biology of the critically endangered birds of Mauritius. M.Sc. thesis. University College of Swansea, United Kingdom. 384 pp.

———. 1987. The larger land-birds of Mauritius. Pp. 208–300, *in* A. W. Diamond, ed. Studies of Mascarene Island birds. Cambridge University Press, Cambridge, United Kingdom. 458 pp.

———, AND A. W. OWADALLY. 1988. The life histories and conservation of the Mauritius Kestrel *Falco punctatus*, pink pigeon *Columba mayeri*, and echo parakeet *Psittacula eques*. Proceedings of the Royal Society of Arts and Science 5:81–130.

———, W. HECK, R. E. LEWIS, Y. MUNGROO, AND T. J. CADE. 1991. A summary of the conservation management of the Mauritius Kestrel *Falco punctatus* 1973–1991. Dodo 27: 81-99.

KENWARD, R. E. 1978. Radio transmitters tail-mounted on hawks. Ornis Scand. 9:220–223.

———. 1980. Radio monitoring birds of prey. Pp. 97–104, *in* C. J. Amlaner and D. W. McDonald, eds. A handbook on biotelemetry and radio tracking. Pergamon Press, Oxford, United Kingdom. 804 pp.

LORENCE, D. H., AND R. W. SUSSMAN. 1988. Diversity, density, and invasion in a Mauritian wet forest. Monogr. Syst. Bot. 25:187–204.

MACDONALD, D. W., F. G. BALL, AND N. G. HOUGH. 1980. The evaluation of home range size and configuration using radio-tracking data. Pp. 405–424, *in* C. J. Amlaner and D. W. MacDonald, eds. A handbook on biotelemetry and radiotracking. Pergamon Press, Oxford, United Kingdom. 804 pp.

SCHOENER, T. W. 1981. An empirically based estimate of home range. Theor. Popul. Biol. 20: 281–325.

SWIHART, R. K., AND N. A. SLADE. 1985. Testing for independence of observations in animal movements. Ecology 66:1176–1184.

TEMPLE, S. A. 1974. Wildlife in Mauritius today. Oryx 13:584–590.

———. 1977. Status and conservation of endemic kestrels on Indian Ocean islands. Pp. 74–81, *in* R. D. Chancellor, ed. Report of Proceedings of World Conference on Birds of Prey, Vienna, 1–3 Oct. 1975. ICBP, London, United Kingdom. 442 pp.

———. 1987. Foraging ecology of the endangered Mauritius Kestrel (*Falco punctatus*). Biotropica 19:1–6.

VAUGHAN, R. E., AND P. O. WIEHE. 1937. Studies on the vegetation of Mauritius. I. A. preliminary survey of the plant communities. J. Ecol. 25:289–343.

———, AND ———. 1941. Studies on the vegetation of Mauritius. III. The structure and development of the upland climax forest. J. Ecol. 29:127–160.

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